Weekly Report

***Period**: 05/27/2013 – 06/02/2013*

Projects

No great progress has been achieved in this week.

Research

Fiber tracking is an important approach for studying the underlying fibrous structures of tissues. However, this technique yields to the plight of tuning parameters. The trial-and-error process is very cumbersome. Thus, tuning a good tracking configuration remains a great challenge in this literature. Typically, different patients have different tracking configurations.

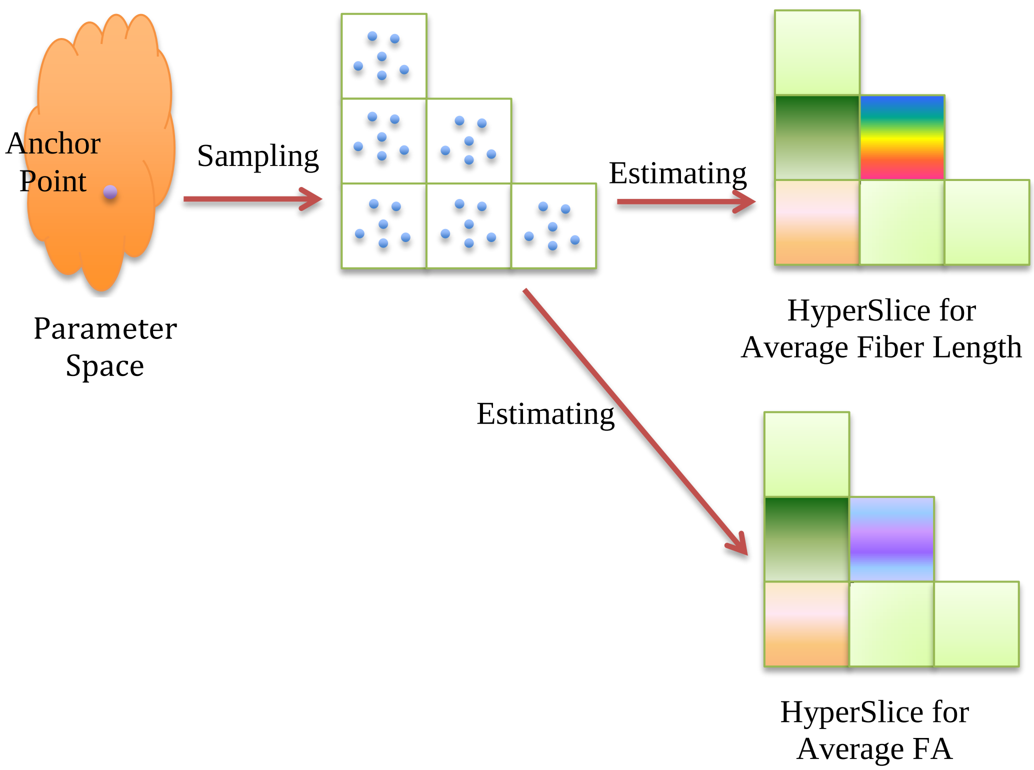
We propose a framework to study the parameter space based on Gaussian Process Model. More specifically, our framework consists of the following steps:

1) We start by sparsely sampling the entire parameter space $\mathrm{P} = \{(p_1, p_2, \dots, p_m)\}$, where p_i represents a parameter associated with range $R_i = [l_i, u_i] \subset \mathbb{R}$. Because the dense sampling scheme such as uniform sampling would give rise to high expense of fiber tracking, even it can bring good overall estimation. We would like to reduce the runs of fiber tracking procedures while obtaining a good overall idea of the resulting manifold. Thus, we choose to use the Latin Hypercube Sampling (LHS) [1] method as our basic sampling technique which has the ability to guarantee that all sample points are uniformly distributed on each dimension. Heuristically, at least n=10*k points are needed [3] with LHS. Here, k is the dimensionality of the parameter space. For convenience, we refer to the initial parameter vectors as $\mathbf{X} = \{\boldsymbol{x_1}, \boldsymbol{x_2}, \dots, \boldsymbol{x_n} | \boldsymbol{x_i} \in \mathbb{R}^m\}$.
2) Once we get the initial parameter vectors $\mathbf{X}$, we can run our fiber tracking procedure to generate a set of fiber models $\mathrm{F} = \{f_1, f_2, \dots, f_n\}$. By analyzing the medical features (such as average fiber length et.al.[4]) for each fiber model in F, the user can easily gain a preliminary insight of the influence of parameters for fiber tracking. Further, the user can navigate to a specific parameter vector $\boldsymbol{x_i}$ to explore the impact that the parameters bring to the resulting fiber models.
3) We refer to the chosen parameter vector $\boldsymbol{x_i}$ as anchor point $\boldsymbol{\Upsilon}$ for investigation. Alternatively, the user can define an anchor point by themselves according to their prior domain knowledge. For example, mostly the user will set the curvature threshold for fiber tracking to 85 degrees.
4) Once an anchor point defined, a HyperSlice representation is employed to show the estimated response surfaces. Each plot in the HyperSlice represents a response surface on tow specific parameters (p_i, p_j) by keeping all other parameter fixed to the anchor point $\boldsymbol{\Upsilon}$. To estimate the response surface, we first sparsely sample the subspace $\mathrm{S} = \{(p_i, p_j)\}, \mathrm{S} \subset \mathbb{R}^2$ defined by (p_i, p_j) with LHS. Then, the Gaussian Process Model is adopted to predict the unknown response.

Generally, our HyperSlice representation is endowed with the following abilities:

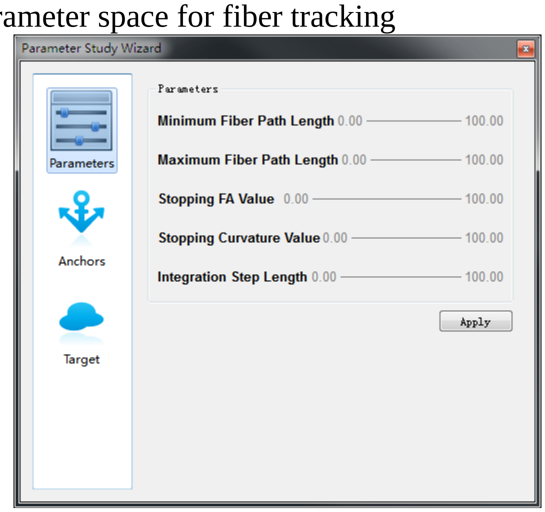
- ✓ Locate range of interest for each parameter
- ✓ Find optimal tracking parameter configurations
- ✓ Analyze the relationship of between pairs of parameters

The following schematic figure shows the pipeline of our framework to study parameter of fiber tracking.

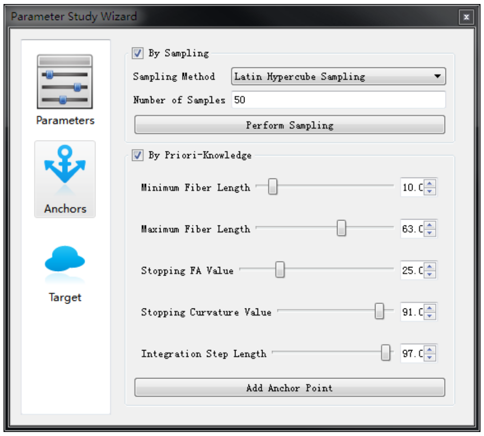


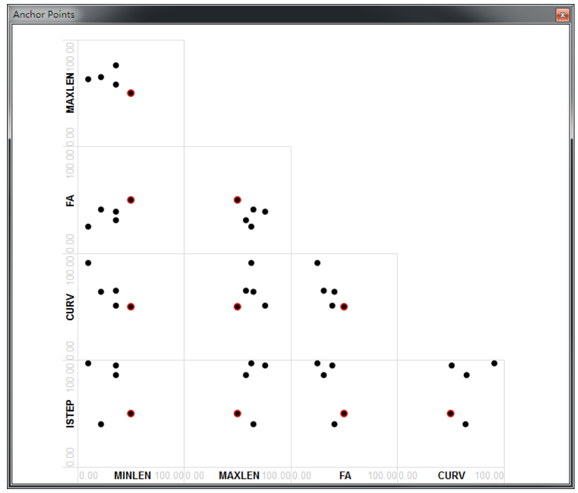
The wizard to study how tracking parameters can influence the resulting tractography:

Step1: Defining the parameter space for fiber tracking

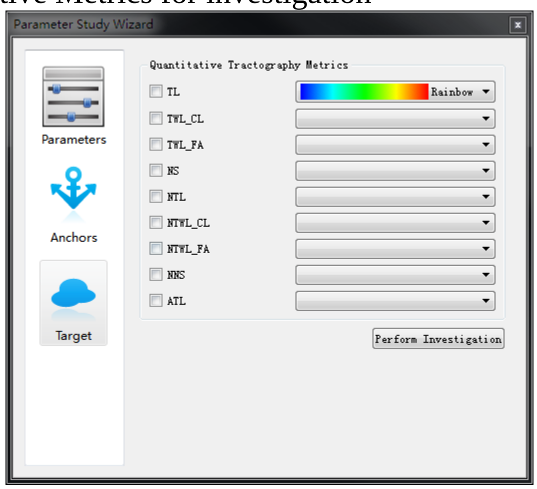


Step2: Defining the anchor points for investigation



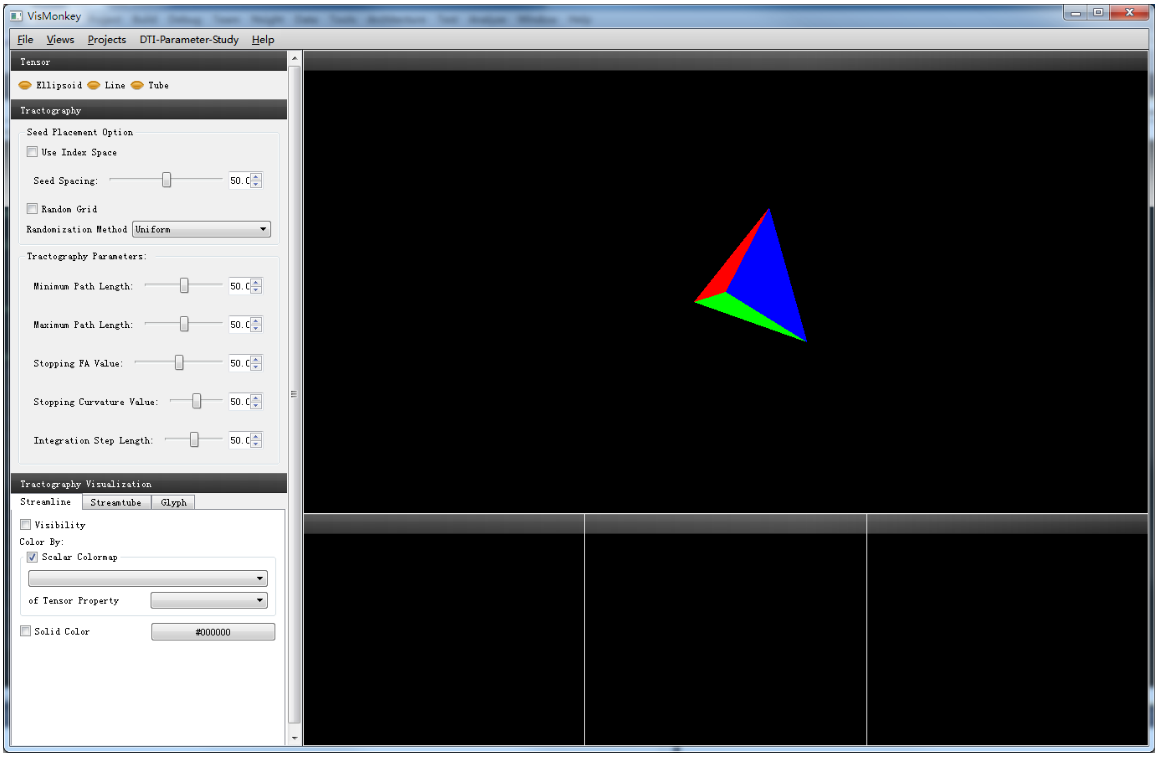


Step3: Choose Quantitative Metrics for investigation



Step4: Investigation based on HyperSlice representation
A Zoomable user interface will be employed for exploration, which is in progress.

Step5: The conventional DTI exploration tool is provided to study a specific tacking result



Work to be done in next week

- To make good use of the statistical packages (such as [1,2]) provided by R, I have to find the call interface for c++
- Implement the nrrd file reading part
- Finish the application of Patent Energy-saving work
- Finish the slides for China Meteorological Administration

Reference:

[1] lhs: Latin Hypercube Samples. http://cran.r-project.org/web/packages/lhs/index.html
[2] mlegp: Maximum Likelihood Estimates of Gaussian Processes. http://cran.r-project.org/web/packages/mlegp/index.html
[3] Efficient Global Optimization of Expensive Black-Box Functions.
[4] Quantitative tractography metrics of white matter integrity in diffusion-tensor MRI.